The BNL Deep Ultra-Violet Free Electron Laser: Current Status and Plans

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Seeded Beam - FEL . . .

Weds the best of lasers and accelerators :

Seed laser properties imposed on electron beam

- Mode structure and coherence
- Bandwidth
- Frequency stability
- Flexibility in pulse timing and sculpting

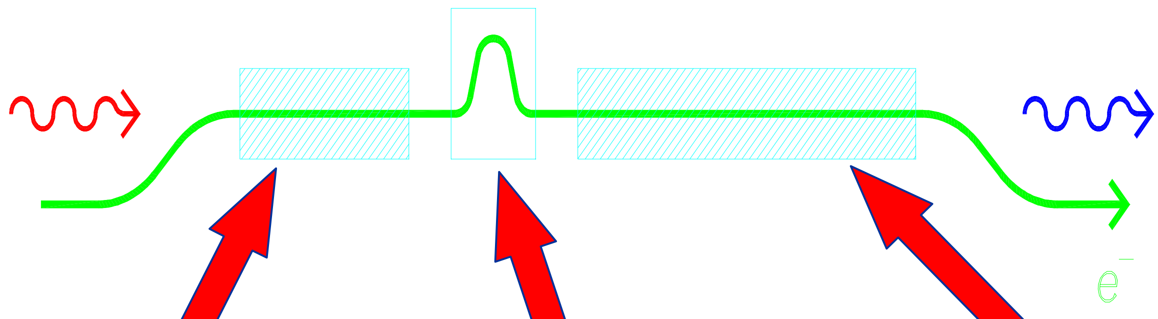
Harmonic generation and single pass amplification

- Extend laser capability to short wavelength
- Provide properties required for useful source

Potential technology for Advanced X-ray Sources

The HGHG Experiment

Seed Laser
λ=10.6μm
P_{pk}=0.7 MW



HGHG FEL
λ=5.3 μm
P_{pk}=35 MW

Modulator Section

B_w=0.16T λ_w=8cm L=0.76 m

Dispersion Section

L=0.3 m

Radiator Section

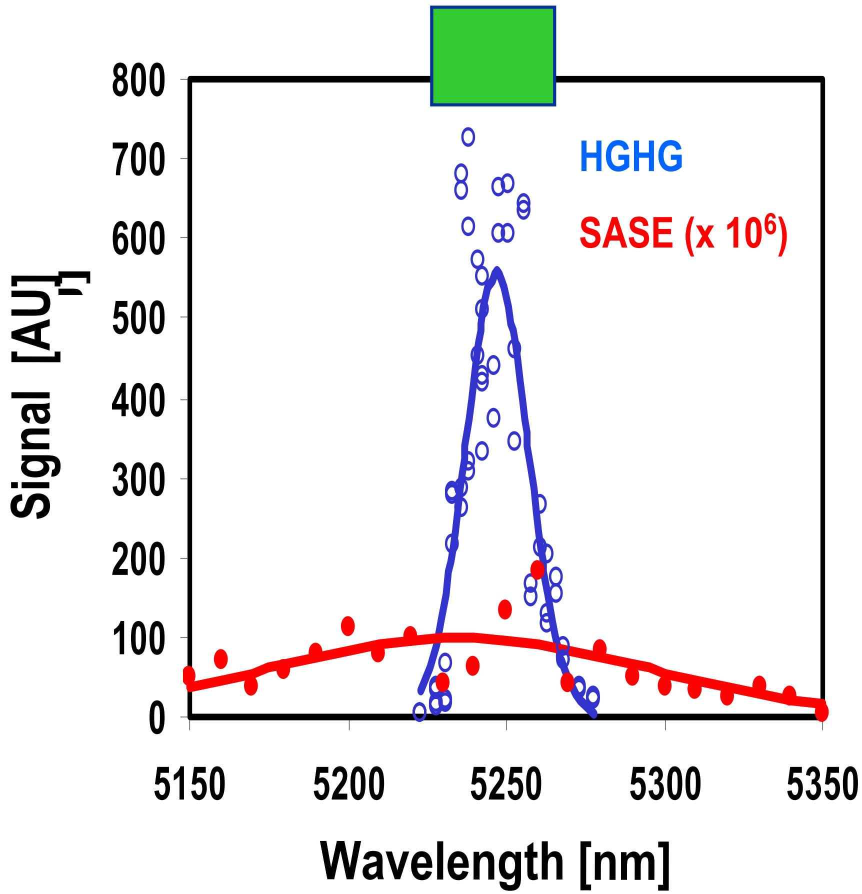
B_w=0.47T λ_w=3.3cm L=2 m

Electron Beam Input Parameters: E= 40 MeV

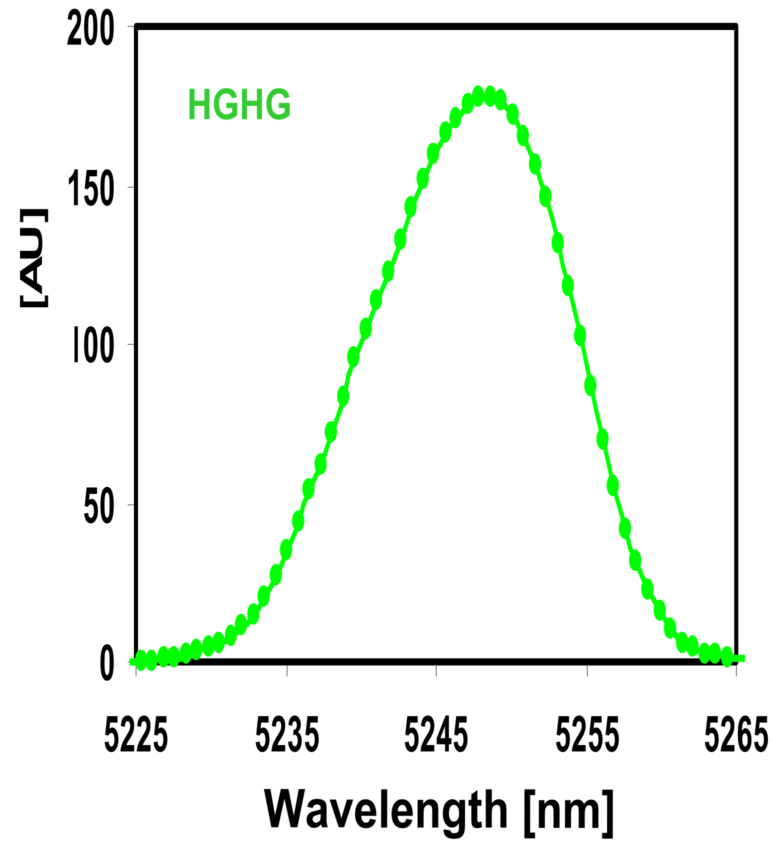
ε_n= 4π mm-mrad dγ/γ=0.043% I = 110A τ_e= 4 ps

Comparison of SASE and HGHG

Multi-Shot Spectrum



Single Shot Spectrum



Role of the DUV-FEL

Function

The project objective is to facilitate the *coordinated development* of sources and experiments to produce and utilize coherent sub-picosecond ultra-violet light

Features

Experience base from the NSLS and ATF

Recovered equipment; 200 MeV Linac (SXLS) and 10m long Undulator (NISUS)

Breadth of collaborators (DOE Labs, Universities, Industry)

Technology coupled with the Linac Coherent Light Source (LCLS) collaboration

Advanced Source Development at Modest Cost

Fundamental contributions to pursuit of ‘Fourth Generation Light Sources’

DUV-FEL Research Opportunities

UV-VUV Photochemical Research

Fundamental problems addressed by direct excitation

Quantum Control

Fundamental study of energy transfer and distribution in chemical reactions

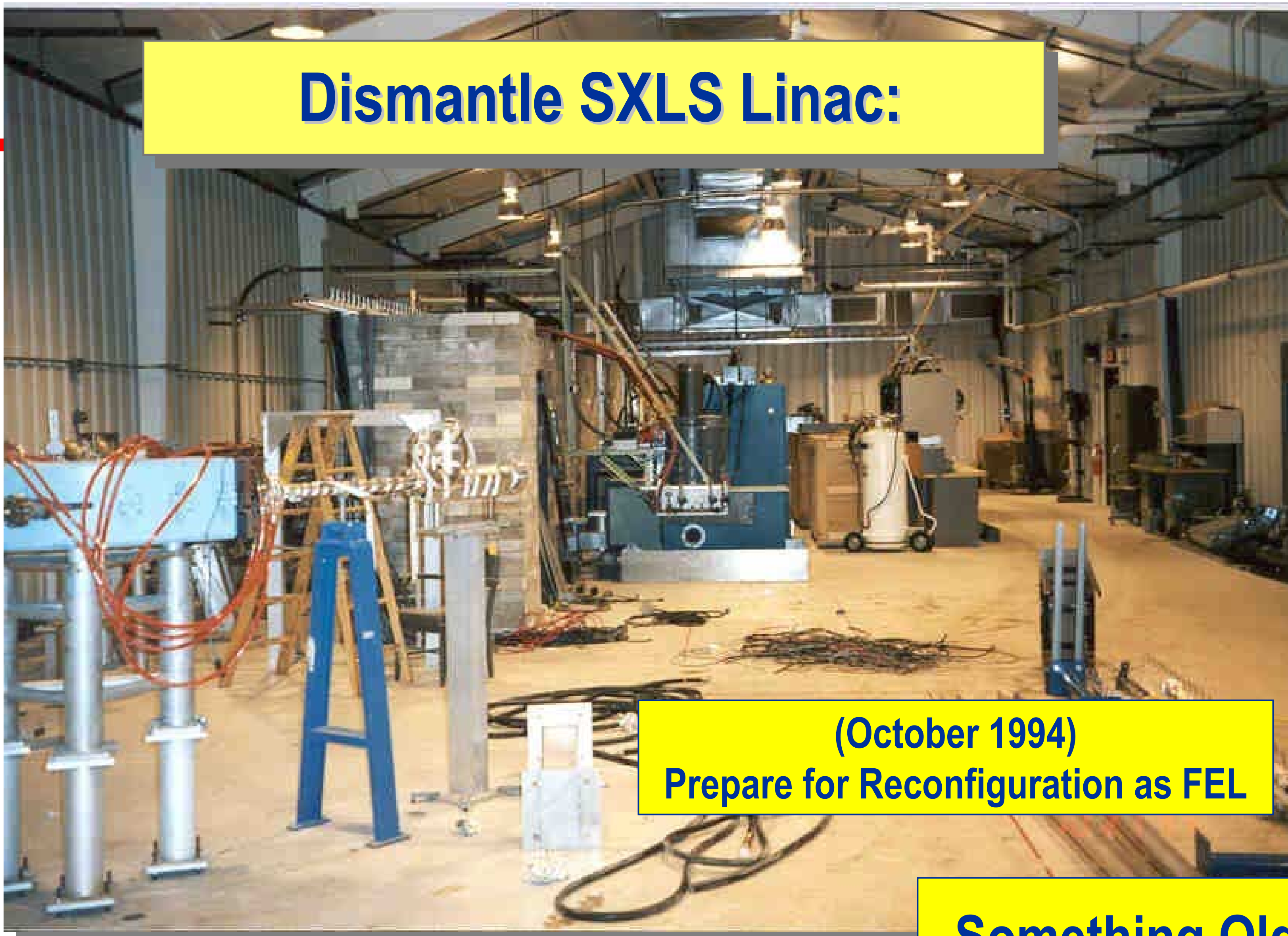
Non Linear Optics at Short Wavelengths

Fundamental test of Atom-Laser Interactions in high frequency region

FEL Technology Development

Fundamental contributions to pursuit of 'Fourth Generation Light Sources'

Dismantle SXLS Linac:



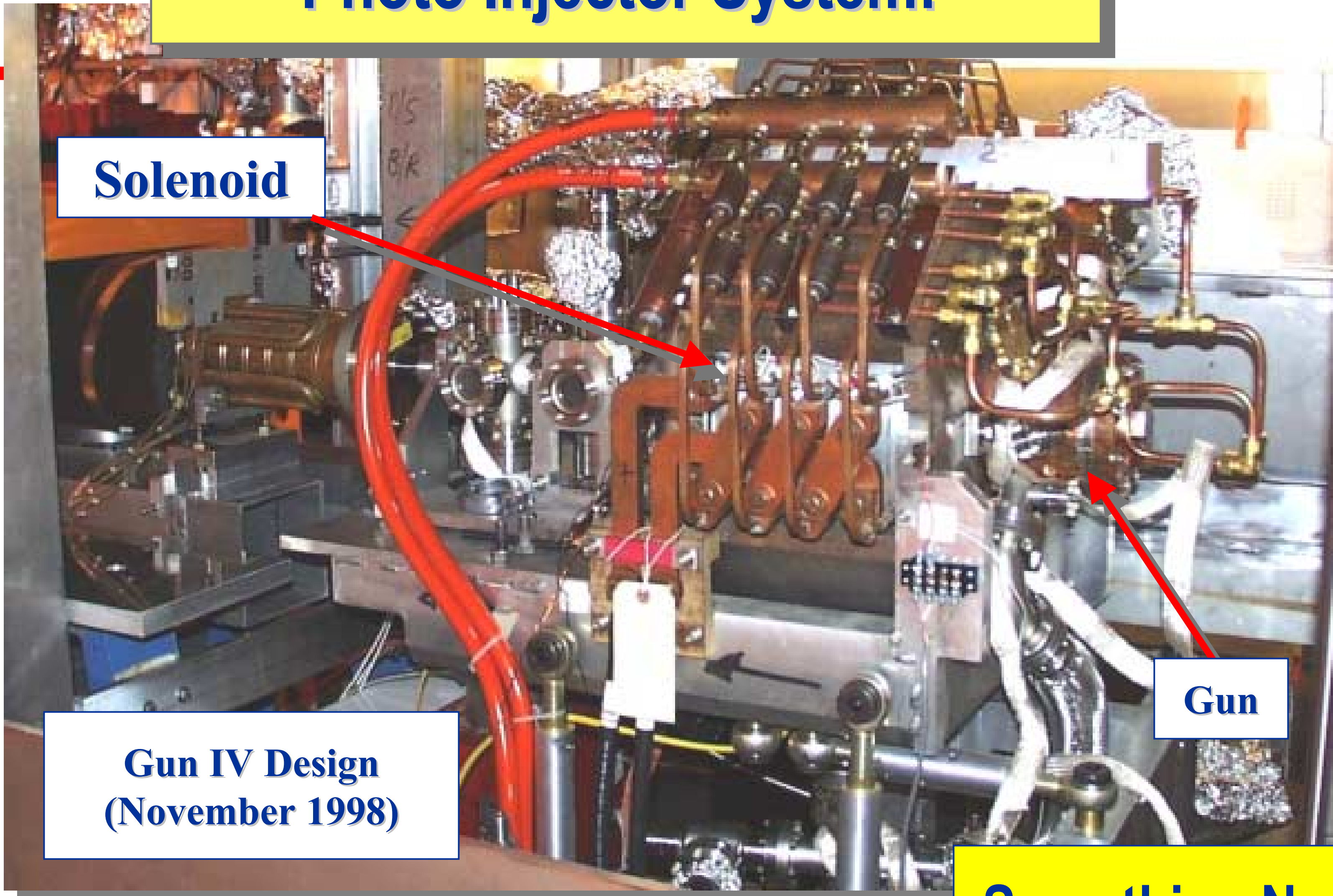
(October 1994)
Prepare for Reconfiguration as FEL

Something Old

Something Borrowed (and Blue)

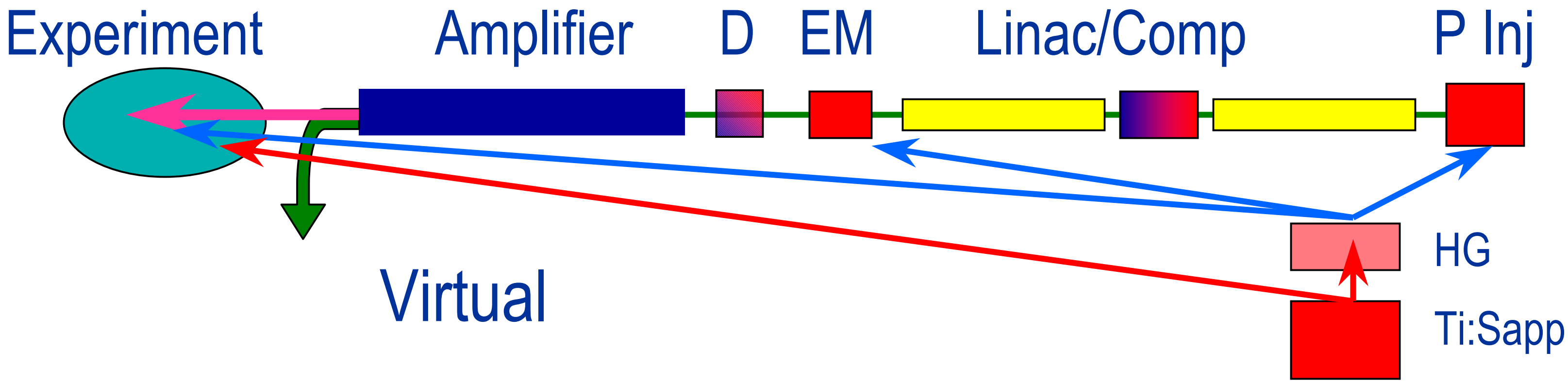
NISUS Arrives
December 1994

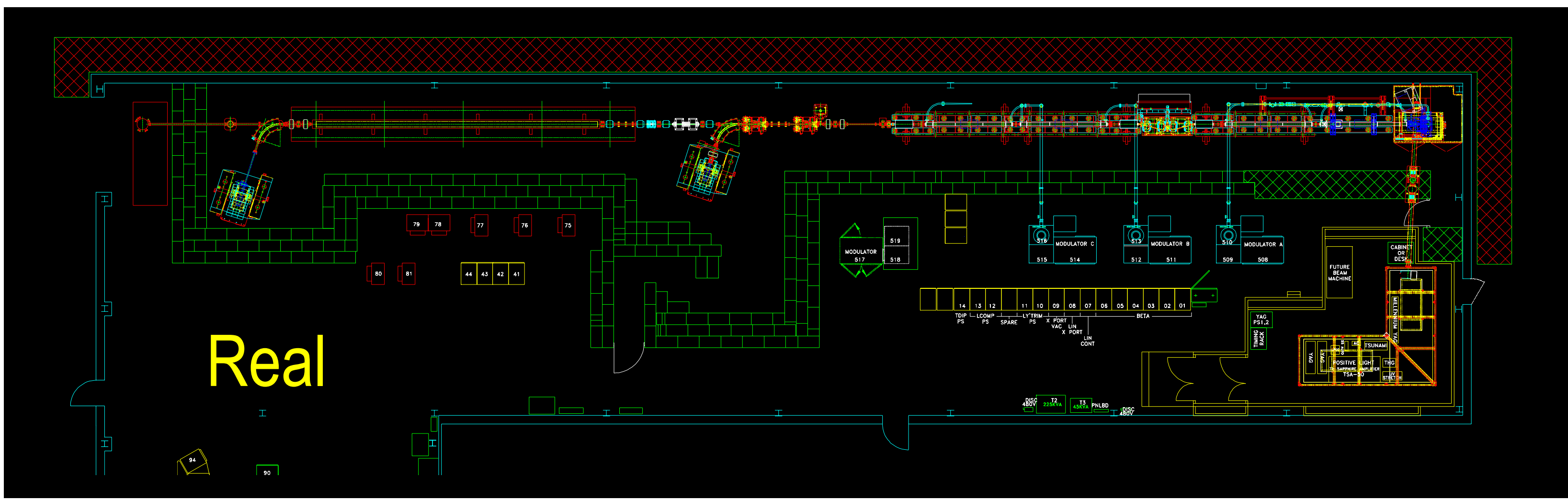
Photo Injector System:



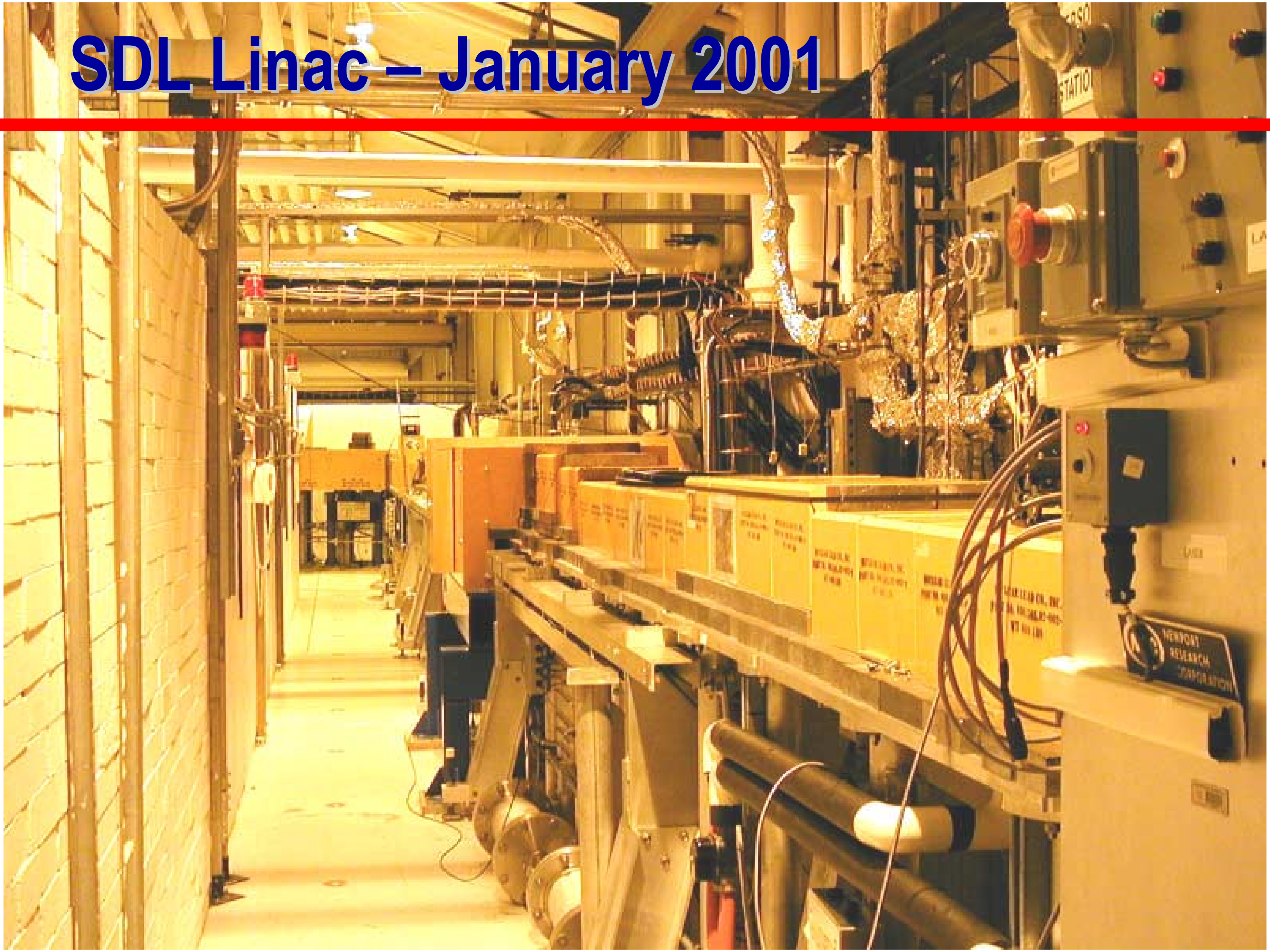
Something New

BNL Deep UltraViolet-Free Electron Laser



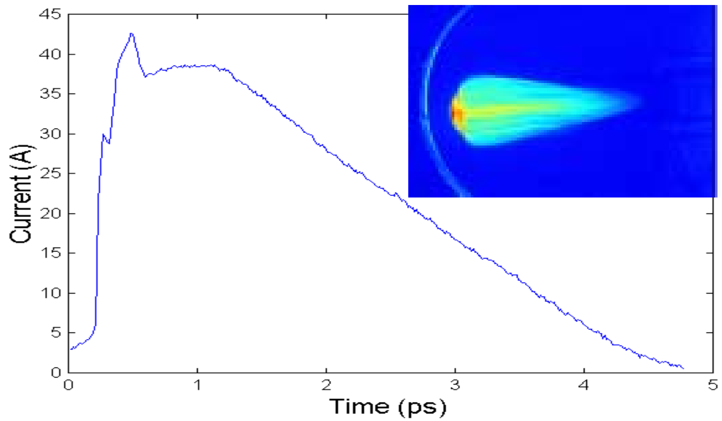


SDL Linac – January 2001

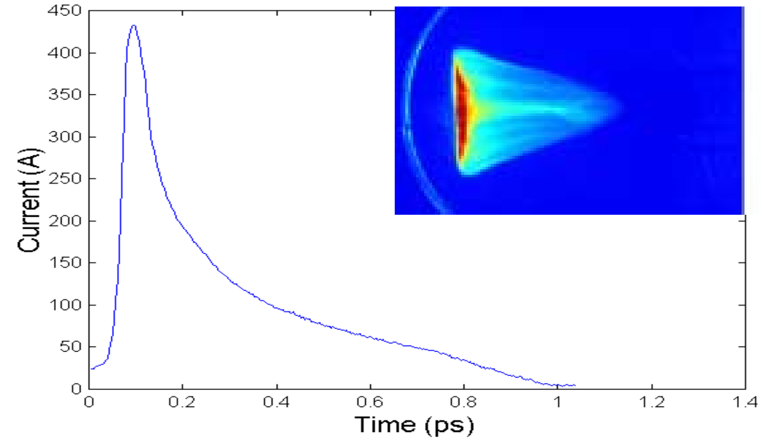


SDL Electron Beam Studies:

Uncompressed, 40 A peak, 3 ps FWHM



Compressed, 450 A peak, 0.2 ps FWHM



Beam Parameters		Compressor	Linac	Visible	Lattice Studies
Energy	[MeV]	82	200	140	195
Energy Spread	[%]	0.2	0.07	0.1	0.08
Bunch Length	[ps]	2-3	0.2-3	1.0	~4
Charge	[pC]	100	100	400	250
Emittance	[mm-mrad]	4-8	4-8	5	~3 at 80 MeV
Timing Stability	[ps]	0.5-3	0.5-3		

DUV-FEL: Near Term Plans

<u>Linac Operation</u>

- Conditioning of Linac
- Implementation of Photocathode Laser System

<u>Experimental Program</u> (Multiple Collaborations)

- Compressor Performance Studies
- CSR/CSCF Studies
- Edge Radiation Measurements

<u>FEL Program Development</u>

- Measure and prepare NISUS
- Prepare Optical Systems for Beam Analysis
- Beam Seeding Development

DUV-FEL: Challenges Ahead

Timing Stability

- Compressor Performance (Current and Energy)
- Synchronization for Pump-Probe

Resonant Processes

- Threshold spectroscopies (Wavelength Stability)
- Excited States (Harmonic Content)

Pump-Probe Capabilities

- Multi-color Synchronization and Metrology
- Complimentary source matching

Cost & Performance Issues for Shorter Wavelengths

- Energy and Repetition Rate Upgrades
- Amplifier Upgrades

Some Proposed Experiments for the DUV-FEL

- Atomic and Molecular Stabilization in Superintense Fields
  M. Gavrila FOM Institute for Atomic and Molecular Physics
- UV Radiation Damage of DNA: Pump-Probe Kinetics of Transient reaction Intermediates
  L.A. Kelly U. of Maryland Baltimore County and J.C. Sutherland BNL
- UV-FEL Detector in an IR Laser Molecular Beam Spectrometer
  G. Scoles Princeton
- Elementary Combustion Reactions of Phosphonate Compounds
  P.L. Houston Cornell University
- The VUV Photodissociation of CO_2
  P.L. Houston Cornell University
- Photoelectron Spectroscopy of Laser Excited Surface States
  J.P. Long and M.N. Kabler Naval Research Laboratory
- Ultraviolet Resonance Raman Spectroscopy of Proteins
  T.G. Spiro Princeton University
- Examining the Structure and Interactions of Proteins by Time-Resolved Phosphorescence
  W.R. Laws and J.B.A. Ross Mt. Sinai School of Medicine
- Matrix Assisted Laser Desorption- Laser Assisted Fragmentation for trace Protein Identification
  M. Chance Albert Einstein College of Medicine

The Frontier for the DUV-FEL . . .

- Combining Lasers with Accelerators is ***the*** Key in UV Applications
- Must develop new strategies for Experiments
- Must push frontier in Accelerator Technology